Claims

1. A fuel cell stack for a fuel cell power plant, comprising:

a plurality of fuel cells arranged in a stack, each including a membrane electrode assembly having a proton exchange membrane between a cathode catalyst and an anode catalyst, an anode support plate adjacent said anode catalyst, a cathode support plate adjacent said cathode catalyst, a porous anode water transport plate having a fuel reactant gas flow field adjacent said anode transport plate, and a porous cathode water transport plate having an oxidant reactant gas flow field adjacent to said cathode support plate, at least one of said water transport plates in each cell having water flow channels;

a plurality of solid plates, selected from one or more of solid cooler plates and solid separator plates, disposed between at least some of said cells in said stack; and

water transfer means disposed in each of said fuel cells for transferring water only internally within said stack from said cathode water transport plate of at least one of said fuel cells to at least one of said anode water transport plates which may be within said one fuel cell or a different fuel cell.

2. A fuel cell stack according to claim 1 wherein said at least one said anode water transport plates is in said different fuel cell and said one cell and said different cell are each disposed adjacent to one of said solid plates.

3. A fuel cell stack according to claim 1:

wherein each of said water transport plates which is contiguous with one of said solid plates has a water flow field adjacent to said contiguous solid plate.

4. A fuel cell stack according to claim 1 wherein there are between two and five of said fuel cells between successive pairs of solid cooler plates.

5. A fuel cell stack according to claim 4 wherein there are between one and four solid separator plates between successive pairs of said cooler plates.

6. A fuel cell stack according to claim 5 wherein said water transfer means comprises at least one internal water manifold which extends completely through each of said fuel cells and each of said solid separator plates, and is in liquid communication with said porous water transfer plates.

7. A fuel cell stack according to claim 4 wherein said water transfer means comprises at least one internal water manifold which extends completely through each of said fuel cells and each of said solid cooler plates, said at least one manifold in liquid communication with said porous water transport plates.

8. A fuel cell stack according to claim 1 wherein said water transfer means comprises at least one internal water manifold which extends throughout said fuel cell stack exclusive of the first solid plate at one end of said stack and the last solid plate at an end

opposite of said stack, said at least one manifold in liquid communication with said porous water transport plates.

9. A fuel cell stack according to claim 1 wherein said water transfer means comprises a high water permeability proton exchange membrane.

10. A fuel cell stack according to claim 9 wherein said membrane has a microporous water-filled phase in excess of 10 volume %.

11. A fuel cell stack according to claim 9 wherein said membrane has a microporous water-filled phase between 15 volume % and 25 volume %.

12. A fuel cell stack according to claim 1 wherein said water transfer means comprises a water transport band constructed of a particle that is wettable, non-conductive and has a particle size of 5 microns or less, said band extending from said cathode water transport plate to said anode water transport plate.

13. A fuel cell stack according to claim 12 wherein said water transfer band comprises silicon carbide.

14. A fuel cell stack according to claim 13 wherein said silicon carbide is screen printed onto a support plate of said fuel cell in sufficient thickness so as to accommodate the thickness of said support plates and said catalysts.

15. A fuel cell stack according to claim 13 wherein holes are provided in said water transport plates to conduct water from said water flow fields to said water transfer band.

16. A fuel cell stack according to claim 1 wherein porous water transfer zones are adjacent to at least one edge of said at least one fuel cell, said water transfer zones are contiguous and in water communication with said at least one edge of said cathode water transport plate and with said at least one edge of said anode water transport plate.

17. A fuel cell stack according to claim 16 wherein said water transfer zone includes a flow restriction between said cathode water transport plate and said anode water transport plate.

18. A fuel cell stack according to claim 1 wherein about 90% of product water generated at the cathodes of said fuel cells is removed from said stack as vapor in exhaust of said oxidant reactant gas flow field, about 30% of product water generated at the cathodes of said fuel cells is transferred wholly within said stack from said cathode water transport plates of said stack to the anode water transport plates of said stack, and about 10% of the product water generated at the cathodes of said fuel cells is expelled as liquid water through exhaust of said anode water transport plates.

19. A method of operating a fuel cell stack without external water management apparatus, said method comprising:

expelling 80%-95% of product water generated at the cathodes of the fuel cells of said stack as vapor in the exhaust of said oxidant reactant gas flow fields;

transferring, by means of at least one water transfer path within said stack, between 25% and 40% of product water generated at the cathodes of said fuel cells from said cathode water transport plates of said fuel cells to said anode water transport plates of said fuel cells; and

removing between 5% and 15% of product water generated at the cathodes of said fuel cells to exhaust from said anode water transport plates.

20. A method of operating a fuel cell power plant having a stack of fuel cells, each fuel cell including a membrane electrode assembly having a proton exchange membrane between a cathode catalyst and an anode catalyst, an anode support plate adjacent said cathode catalyst, a cathode support plate adjacent said cathode catalyst, a porous anode water transport plate having fuel reactant gas flow field adjacent said anode transport plate, and a cathode water transport plate having an oxidant reactant gas flow field adjacent to said cathode support plate, at least one of said water transport plates of each cell having water flow channels, and a plurality of solid plates, selected from one or more of solid cooler plates and solid separator plates, disposed between at least some of said cells, said method comprising:

transferring water only internally within said fuel cell stack from said cathode water transport plate of at least one of said fuel cells to at least one of said anode water transport plates which may be within said one fuel cell or a different fuel cell.

21. A method of operating a fuel cell power plant having a stack of fuel cells, each fuel cell including a membrane electrode assembly having a proton exchange membrane between a cathode catalyst and an anode catalyst, an anode support plate adjacent said cathode catalyst, a cathode support plate adjacent said cathode catalyst, a porous anode water transport plate having fuel reactant gas flow field adjacent said anode transport plate, and a cathode water transport plate having an oxidant reactant gas flow field adjacent to said cathode support plate, the anode water transport plates of each cell having water flow channels, a plurality of solid cooler plates separating said fuel cells into groups of between 2 and 6 fuel cells per group, each of said cathode water transport plates adjacent to one of said solid cooler plates also having water flow channels, said method comprising conducting water only internally within said fuel cell stack from a cathode water transport plate at a first end of said fuel cell stack to an anode water transport plate at a second end of said fuel cell stack opposite said first end through at least one internal water manifold in liquid communication with all of said water transport plates.